MULTIMEDIA UNIVERSITY®

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2017/2018

PPH0105 – MODERN PHYSICS & THERMODYNAMICS

(Foundation in Engineering)

4 JUNE 2018
2.30 p.m – 4.30 p.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of **FIVE** printed pages, excluding the cover page and appendixes, with **FIVE** questions.
2. Answer **ALL** questions. The distribution of the marks for each question is given.
3. Write all your answers in the Answer Booklet provided.
4. All necessary workings **MUST** be shown.

ANSWER ALL QUESTIONS

QUESTION 1 (10 Marks)

a) The equation of a wave in a string is given by

$$y\,(x,t) = (6\text{ cm})\sin(0.02\,\pi x + 4.0\pi t)$$

where x and y are in centimeters and t is in seconds. Determine the speed and frequency of this wave.

(2 marks)

b) A string with a linear density of 7.5 g/m is under a tension of 120.0 N. The fixed supports are 1.8 m apart. The string oscillating in the standing wave pattern shown in **Figure Q1.1**. Calculate the speed, wavelength and the frequency of the traveling waves whose superposition give this standing wave.

(3 marks)

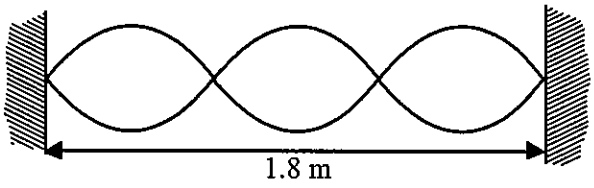

Figure Q1.1

c) Two loud speakers are placed on x-axis as shown in **Figure Q1.2** and driven by the same source at a frequency of 500.00 Hz. An observer is in front of the speakers at point P at the same distance from each speaker. How far to the left speaker A must be moved (on the x-axis) so that the observer at point P experiences the first destructive interference? (The speed of sound in air is 340.0 m/s).

(5 marks)

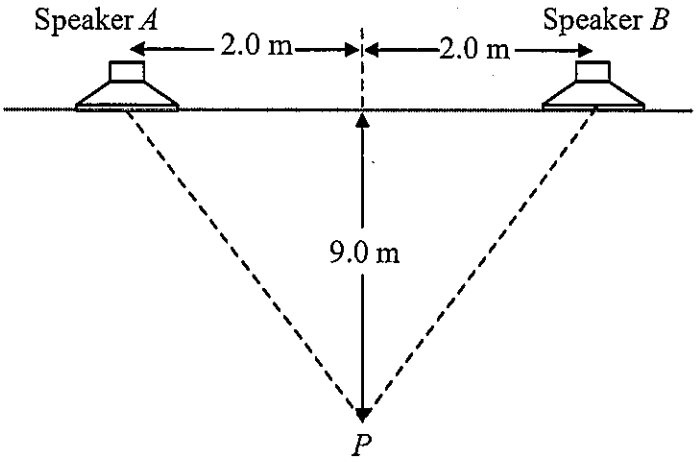

Figure Q1.2

Continued...

QUESTION 2 (10 Marks)

a) Laser light with a wavelength of 632.8 nm is directed through one slit or two slits and allowed to fall on a screen 2.60 m beyond. **Figure Q2.1** shows the pattern on the screen with a centimeter ruler below it.

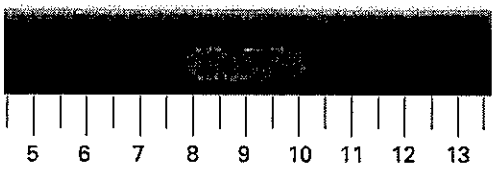

Figure Q2.1

(i) Did the light pass through one slit or two slits? Explain how you can tell. (2 marks)

(ii) If one slit, find its width. If two slits, find the distance between their centers. (2 marks)

b) A waterproof laser is immersed in water. **Figure Q2.2** shows the laser shining light up towards the horizontal surface of the water.

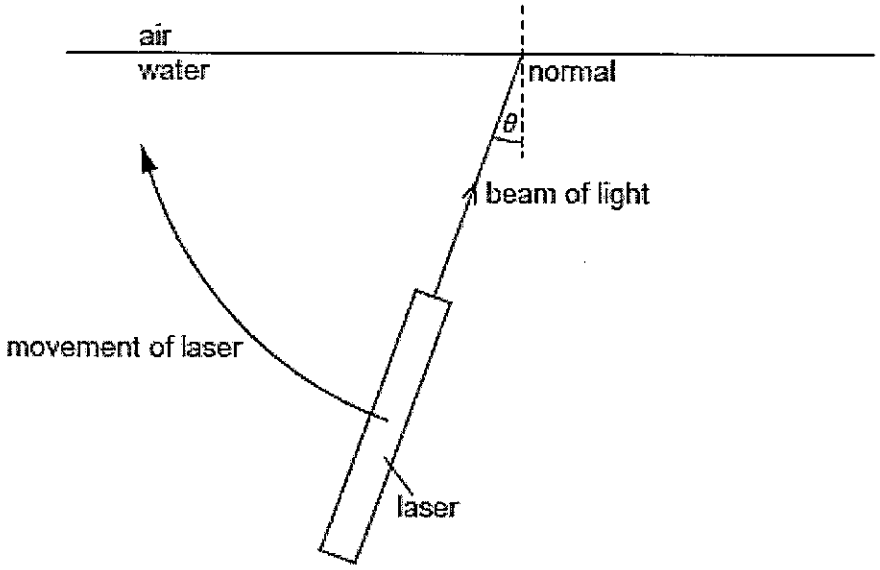

Figure Q2.2

Initially, the angle θ is much less than the critical angle for this light in water. The laser moves and θ gradually increases until it is much greater than the critical angle. Describe, for different angles of the laser, what happens to the light beam after it hits the surface.

(3 marks)

Continued...

c) A lens forms an image of an object. The object is 16.0 cm from the lens. The image is 12.0 cm from the lens on the same side as the object. What is the focal length of the lens? Is the lens converging or diverging?

(3 marks)

QUESTION 3 (10 Marks)

a) **Table Q3** shows the ranges of wavelength and frequency of different electromagnetic waves.

Electromagnetic Spectrum		Frequency (Hz)			Wavelength		
Radio waves		Less than		3×10^{11}	Above		0.3 m
Microwave		10^9	to	3×10^{11}	0.3 m	to	1 mm
Infrared		3×10^{11}	to	3.8×10^{14}	1 mm	to	789 nm
	Red	3.8×10^{14}	to	4.8×10^{14}	789 nm	to	625 nm
	Orange	4.8×10^{14}	to	5×10^{14}	625 nm	to	600 nm
	Yellow	5×10^{14}	to	5.2×10^{14}	600 nm	to	577 nm
Visible	Green	5.2×10^{14}	to	6.1×10^{14}	577 nm	to	491 nm
	Blue	6.1×10^{14}	to	6.59×10^{14}	491 nm	to	455 nm
	Violet	6.59×10^{14}	to	8×10^{14}	455 nm	to	390 nm
Ultraviolet		8×10^{14}	to	2.4×10^{16}	390 nm	to	8.82 nm
X ray		2.4×10^{16}	to	5×10^{19}	8.82 nm	to	6 pm
Gamma ray		Above		5×10^{19}	Less than		6 pm

Table Q3

With refer to electromagnetic spectrum given in **Table Q3**, if green light causes the ejection of electrons from a metal in a photoelectric effect experiment and yellow light does not,

(i) what would you expect to happen if red light were used to illuminate the same metal?

(1 mark)

(ii) Do you expect more intense yellow light to eject electrons? Explain.

(2 marks)

(iii) What about very faint violet light? Explain.

(2 marks)

Continued...

b) The first three energy levels of the fictitious element *X* are shown in **Figure Q3**.

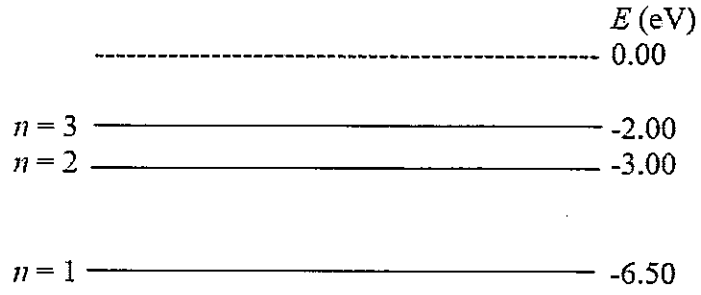

Figure Q3

(i) What is the ionization energy of element *X*?

(1 mark)

(ii) If the element is initially at a ground state, what wavelengths are observed in the absorption spectrum of element *X*?

(4 marks)

QUESTION 4 (10 Marks)

a) (i) What is meant by isotopes?

(1 mark)

(ii) List the three isotopes of hydrogen.

(1.5 marks)

b) (i) Define the half-life of a radioactive sample.

(1 mark)

(ii) A sample of the isotope ^{131}I has a half-life of 8.04 days. It has an activity of 5.0 mCi at the time of shipment. The activity is 2.5 mCi upon receipt of this sample at a medical laboratory. How much time elapsed between the two measurements?

(2.5 marks)

c) (i) Identify the missing nuclide (X) in the beta decay process below:

$$^{14}_{6}C \rightarrow X + e^{-} + \bar{\nu}$$

where $\bar{\nu}$ is the antineutrino.

(1 mark)

(ii) A nucleus that undergoes radioactive decay is left in an excited energy state (*X**) and then undergoes a second decay to a lower energy state (i.e. ground state) by emitting a high-energy photon. What is the type of the radioactive decay process mentioned in this statement?

(1 mark)

Continued...

(iii) Is there any change in the atomic number, Z in the decay process in part (ii)?
(1 mark)

d) Nuclear fission occurs when a heavy nucleus, ^{235}U splits into two smaller nuclei. What are the two requirements to satisfy the nuclear fission reaction?
(1 mark)

QUESTION 5 (10 Marks)

a) (i) Explain the term called thermal equilibrium.
(1 mark)

(ii) If objects X and Y are separately in thermal equilibrium with a third object Z, then X and Y are in thermal equilibrium with each other. Give a law to this statement.
(1 mark)

b) (i) Define the term called heat.
(1 mark)

(ii) Explain the essential of the specific heat, c of a substance.
(1 mark)

(iii) How much heat input is needed to raise the temperature of an empty 15.0 kg vat made of iron from 10.0°C to 90.0°C? Assume the specific heat of iron is 450.0 J/(kg·°C).
(2 marks)

c) Assume a perfect sphere of helium party balloon has a radius 15.0 cm. Its internal pressure is 1.05 atm at 20.0°C. Determine the number of moles of helium in the balloon.
(3 marks)

d) Heat is transferred from one place to another in three different ways: by conduction, convection and radiation. How does the heat conduction occur in a material?
(1 mark)

End of Page

APPENDIX I

LIST OF PHYSICAL CONSTANTS

Electron mass,	m_e	=	9.11×10^{-31} kg
Proton mass,	m_p	=	1.67×10^{-27} kg
Neutron mass,	m_n	=	1.67×10^{-27} kg
Magnitude of the electron charge,	e	=	1.602×10^{-19} C
Universal gravitational constant,	G	=	6.67×10^{-11} N.m^2 / kg^2
Universal gas constant,	R	=	8.314 J/mol.K
Hydrogen ground state,	E_0	=	13.6 eV
Boltzmann's constant,	k_B	=	1.38×10^{-23}J/K
Compton wavelength,	λ_c	=	2.426×10^{-12}m
Planck's constant,	h	=	6.63×10^{-34}J.s
		=	4.14×10^{-15} eV.s
Speed of light in vacuum,	c	=	3.0×10^8m/s
Rydberg constant,	R_H	=	1.097×10^7m^{-1}
Acceleration due to gravity of earth,	g	=	9.80 m/s^2
1unified atomic mass unit,	1 u	=	931.5 MeV/c^2
		=	1.66×10^{-27} kg
1 electron volt,	1 eV	=	1.60×10^{-19}J
Avogadro's number,	N_A	=	6.023×10^{23} mol^{-1}
Threshold of intensity of hearing,	I_0	=	1.0×10^{-12} W/m^2
Coulomb constant,	$k = \frac{1}{4\pi\varepsilon_0}$	=	9.0×10^9 N.m^2/C^2
Permittivity of free space,	ε_0	=	8.85×10^{-12} C^2/N.m^{-2}
Permeability of free space,	μ_0	=	$4\pi \times 10^{-7}$ T.m/A
1 atmosphere pressure,	1 atm	=	1.0×10^5 N/m^2
			1.0×10^5 Pa
Wein's displacement constant		=	0.2898×10^{-2} m.K
Speed of Sound in Air		=	343 m/s
Refractive index of air/vacuum	n	=	1.0
Earth: Mass,	M_E	=	5.97×10^{24} kg
Radius (mean),	R_E	=	6.38×10^3 km
Moon: Mass,	M_M	=	7.35×10^{22} kg
Radius (mean),	R_M	=	1.74×10^3 km
Sun: Mass,	M_S	=	1.99×10^{30} kg
Radius (mean),	R_S	=	6.96×10^5 km
Earth-Sun distance (mean),		=	149.6×10^6 km
Earth-Moon distance (mean),		=	384×10^3 km

APPENDIX II

LIST OF FORMULAS

$\sin\theta_1 + \sin\theta_2 = 2\sin ½(\theta_1 + \theta_2)\cos ½(\theta_1 - \theta_2)$

$\cos\theta_1 + \cos\theta_2 = 2\cos ½(\theta_1 + \theta_2)\cos ½(\theta_1 - \theta_2)$

$\sin\left(\theta + \frac{\pi}{2}\right) = \cos\theta$

$\sin\theta \approx \tan\theta \approx \theta$ *rad* for small angle

$D(x, t) = D_M \sin(kx \pm \omega t \pm \phi)$

$v = \sqrt{\frac{F_\tau}{\mu}}$ $\quad$ $v = \sqrt{\frac{\text{elastic property of the medium}}{\text{inertia property of the medium}}}$

$\lambda_n = \frac{2}{n}L$ $\quad$ $f' = f\left(\frac{v \pm v_o}{v \mp v_s}\right)$ $\quad$ $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$

$\frac{1}{f} = (n-1)\left\{\frac{1}{R_1} + \frac{1}{R_2}\right\}$ $\quad$ $d\sin\theta = m\lambda$ $\quad$ $d\sin\theta = \left(m + \frac{1}{2}\right)\lambda$

$\lambda_m T = 0.2898 \times 10^{-2}$ $\quad$ $I(\lambda, T) = \frac{2\pi c k_B T}{\lambda^4}$

$E_n = -\frac{mk^2Z^2e^4}{2\hbar^2}\left(\frac{1}{n^2}\right)$ $\quad$ $r_n = \frac{\hbar^2}{mkZe^2}n^2$ $\quad$ $L = mvr_n = n\hbar$ $\quad$ $\hbar = h/2\pi$

$\frac{1}{\lambda} = R_H\left[\frac{1}{n_i^2} - \frac{1}{n_f^2}\right]$ $\quad$ $\frac{1}{\lambda} = \frac{mk^2Z^2e^4}{4\pi c\hbar^3}\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$ $\quad$ $\lambda = \frac{h}{p}$ $\quad$ $\Delta E = hf$

$N = N_0 e^{-\lambda t}$ $\quad$ $R = R_0 e^{-\lambda t}$ $\quad$ $\lambda = \frac{\ln 2}{T_{½}}$ $\quad$ $Q = (M_X - M_Y - M_a)c^2$

$\Delta L = \alpha L_0 \Delta T$ $\quad$ $PV = nRT$ $\quad$ $k = \frac{R}{N_A}$ $\quad$ $Q = mc\Delta T$ $\quad$ $Q = mL$

$\frac{\Delta Q}{\Delta t} = -kA\frac{\Delta T}{\Delta L}$ $\quad$ $\frac{\Delta Q}{\Delta t} = e\sigma AT^4$ $\quad$ $\frac{\Delta Q}{\Delta t} = IeA\cos\theta$

$\overline{\text{KE}} = \frac{1}{2}m\bar{v}^2 = \frac{3}{2}kT$ $\quad$ $U = \frac{f}{2}nRT$ $\quad$ $\Delta U = \frac{f}{2}nR\Delta T$ $\quad$ $Q = \Delta U + W$

$W = \int dW = \int_{V_i}^{V_f} P dV$ $\quad$ $W = P(V_f - V_i)$ $\quad$ $W = nRT\ln\left(\frac{V_f}{V_i}\right)$